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Metallurgy of Bismuth

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By Walter S. Landis.

The most important source of bismuth is the native metal containing small amounts of sulphur and arsenic. The extraction of the metal from such an ore simply requires liquation at low temperature either on hearths or in crucibles. The melting-point of bismuth, 268° C., is much below that of the gangue. The gangue should not be melted in this preliminary separation. Only 90 to 95 per cent. of the bismuth content of the average native ore can be extracted by such liquation. To recover

the remainder, the residue from the liquation furnace or crucible is mixed with enough carbon to insure the reduction of any bismuth oxide that may have formed, and with fluxes like FeO and CaO to insure fusion of the gangue. This mixture is smelted in crucibles or reverberatory furnaces. Oxides of bismuth, such as the ochre, Bi_2O_3, may be treated like this liquation residue for the recovery of the contained bismuth. Bismuth sulphide, Bi_2S_3, is usually fused with scrap iron, forming bismuth and sulphide of iron, mutually insoluble in each other.

Bismuth frequently occurs in lead ores where it is reduced with the lead to a bismuth-lead alloy by the ordinary lead smelting processes. Lead containing bismuth is not suitable for corroding purposes as the bismuth gives the white lead a yellowish tint. The intrinsic value of the bismuth makes it well worthy of separation. The separation of lead and bismuth may be made in a number of ways, all more or less satisfactory. On cupellation of lead containing several per cent. of bismuth, the lead being more easily oxidizable than the bismuth causes a concentration of the bismuth in the lead-silver alloy, the bismuth only commencing to oxidize after the larger part of the lead has been converted into litharge. If the cupellation is so conducted as to remove all the litharge just before the bismuth begins to oxidize, a rich bismuth oxide will be obtained, which can be reduced, afterwards, to a rich bismuth-lead alloy. Litharge containing considerable quantities of bismuth is more or less green.

The Parkes process for the desilverization of lead bullion by means of zinc leaves the bismuth with the lead. The older Pattinson process of desilverization concentrates the bismuth with the enriched silver-lead alloy, leaving the desilverized lead practically free from bismuth. The American Smelting and Refining Company, at its Omaha plant, has just installed a mechanical Pattinsonizing plant for performing such concentration of bismuth in a silver-free lead. The individual pots are supported on hydraulic pistons so as to be raised, the older method of hand ladling being supplanted by direct tapping. The concentration of bismuth into a lead alloy carrying 2 to 6 per cent. bismuth is said to be most satisfactory; there seems to be no real reason why it should not be carried further. This application of the Pattinson principle may give renewed life to an almost obsolete process.

The Betts electrolytic lead refining process separates bismuth from lead, the bismuth remaining with the slime. The lead refinery at Grasselli, Ind., is now the most important producer of bismuth in this country, the entire output coming from the slimes of the lead refinery. No details of the secret process of recovering the bismuth are available for publication, but, judging from the character of the bismuth produced,

the slime is probably melted, cast into anodes, and electrolytically refined by one of the methods, (most likely the chloride) described below. The bismuth is recovered in large nodules which are subsequently melted down to the commercial product.

The raw material for either of the above processes may be bismuth-lead-gold bullion spoken of by S. E. Bretherton[1] as a possible product from Sinaloa, Mexico. The ore contains gold together with 2 per cent. bismuth. On mixing 10 per cent. lead in the charge and smelting in a small lead furnace he recovered 80 to 90 per cent. of the bismuth.

In the older methods of separating lead and bismuth, poling was resorted to for removing small quantities of bismuth. For larger quantities the fusion of the lead-bismuth alloy with bismuth oxy-chloride would remove the lead and leave the bismuth. The oxy-chloride was prepared by dissolving bismuth in nitric acid, converting it to chloride, and precipitating by dilution with a large amount of water.

The electrolytic method of refining bismuth presents a much more attractive scheme. The most successful method has been to cast the crude bismuth into anodes, and suspend them in a solution of bismuth chloride dissolved in hydrochloric acid. The electrolyte should contain about 7 per cent. bismuth and 9 per cent. free hydrochloric acid; anode density, 60 amperes per sq. ft.; cathode density 20 amperes per sq. ft. The electrolyte must be frequently purified, as both lead and silver dissolve in it to a limited extent and plate out if their concentration rises above a few tenths of 1 per cent.

Betts suggests as an electrolyte for the refining of bismuth, 4 per cent. bismuth methylsulphate dissolved in a 10-per cent. solution of methyl-sulphuric acid. No details of the application of this process are at hand and it seems unlikely that such a complicated electrolyte could compete successfully with the simpler chloride bath given above.

In the electrolytic refining of lead by the Betts process the anode slime contains silver and bismuth. In *Zeit. f. Electrochemie,* of April 15, 1910, F. Foerster and E. Schwabe propose to subject this silver-bismuth to a further refining process in a silico-fluoride solution of bismuth as electrolyte. Pure bismuth is deposited on the cathode. The lead contained in the anode passes into the electrolyte. The silver remains at the anode. The bismuth deposited on the cathode is free from lead.

[1] *Eng. and Min. Journ.*, LXXXIX, 773, April 9, 1910.